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ARASAN /IN ENDRIN TREATMENTS TO PROTECT DOUGLAS-FIR SEED FROM DEER MICE,,

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ABSTRACT

In laboratory bioassays, coating with endrin reduced consumption of Douglas-fir seed by deer mice. Coating with Arasan did not lower seed consumption, but endrin plus Arasan reduced feeding to levels comparable with endrin alone. Substitution of talc for Arasan produced similar results. Endrin had little effect on seed germination, but addition of Arasan caused a significant reduction. Increasing amounts of latex adhesive used to bind chemicals to the seed decreased the protective effects of endrin treatments.

Keywords: Endrin, Arasan, rodenticides, Douglas-fir, biological assay.

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INTRODUCTION

Since the 1950's, endrin^{1/} has been widely used by foresters to protect conifer seed from seed-eating rodents (Radwan et al. 1970). A standard treatment consisting of 0.5 percent endrin, an adhesive, 2 percent Arasan (tetramethylthiuram disulphide [TMTD]), and a coloring material, was recommended by the U. S. Bureau of Sport Fisheries and Wildlife in 1956 (Anonymous 1956).

Although field-sown seed treated with endrin germinated successfully in early trials (Dimock 1957, Hooven 1957), many seeding failures have occurred. Consequently, the treatment has been variously modified by changing one or more of the components according to regional or local suggestions, usually with little or no documented basis for the changes.

In the Pacific Northwest, during most of the 1960's, the protective formulation used for Douglas-fir (*Pseudotsuga menziesii*) seed usually contained 1 percent endrin and no Arasan. Apparently, Arasan was eliminated because bird predation was considered minimal and some tests indicated that the chemical did not add significantly to the protective value of the treatment (Dick et al. 1958) and interfered with germination (Shea 1961). During the late 1960's, however, many foresters have reverted to the 1956 formulation (0.5 percent endrin and 2 percent Arasan) despite the lack of new information.

In the South, where much seed is taken by birds in addition to that destroyed by rodents, Arasan (up to 8 percent) is an important component in seed treatments. Much seed of the southern pines (*Pinus spp.*), therefore, has been successfully treated with an endrin-Arasan formulation (Mann 1968).

In this study we reevaluated endrin, Arasan, and endrin-Arasin treatments on Douglas-fir seed using bioassay and germination tests. We used 0.5 percent endrin and 2 to 8 percent Arasan. To ascertain the role of Arasan further, we substituted talc, an inert compound, for the chemical in four tests. In addition, we determined effects of different levels of adhesive on the endrin and endrin-Arasan treatments.

MATERIALS AND METHODS

Seed

One medium-elevation seed lot of Douglas-fir from Pierce County, Washington, was used for all tests. The seed was collected in 1965 and stored at -4° C. During the summer of 1969, 2 pounds of seed were drawn from storage and divided into 1/10-pound subsamples for the different treatments.

Chemicals

Endrin 50-WP (50-percent wettable powder) from Stauffer Chemical Company and Arasan 42-S (42-percent liquid thiram) from the DuPont Company were the active ingredients and talc from the Matheson Company served as an inert compound. Dow Latex 512-R, from the Dow Chemical Company, served as the adhesive, and aluminum powder was used to minimize seed clustering and to identify treated seed.

^{1/} Mention of chemical compounds and chemical companies does not represent endorsement by the U.S. Forest Service or the Department of Agriculture.

Seed treatments

Seeds were treated as follows:

1. *Control (untreated)*: Seed was not chemically treated.

2a, 2b, 2c. 0.5 percent endrin:

Seed was coated with endrin at a concentration of 0.5 percent by weight (1.0 percent of Endrin 50-WP) using 10 ml. of diluted adhesive and 1.2 g. aluminum powder per 100 g. seed. To test the effect of different degrees of binding the chemical to the seed, three treatments were obtained by using different levels of the adhesive. This was achieved by 1:9 (a), 1:4 (b), and 1:1 (c) volume dilutions of the adhesive with water before use.

3. 8.0 percent Arasan: Seed was coated with a volume of liquid Arasan 42-S providing solid Arasan at 8 percent by weight. Undiluted latex and water were added to the Arasan liquid to make the total volume of the mixture and the adhesive solids the same as in treatment 2a. Also, wet seed was coated with 1.2 g. aluminum powder per 100 g. seed.

4a, 4b, 4c. 0.5 percent endrin + 8.0 percent Arasan: Combinations of treatments 2 and 3, using 1.2 g. aluminum powder per 100 g. seed and adding undiluted latex and water, so that amounts of adhesive solids and total volumes of treatment mixture were the same as in treatments 2a, 2b, and 2c, respectively.

5a, 5b, 5c. 0.5 percent endrin + 4.0 percent Arasan: Same as treatments 4a-c, but with half the amounts of Arasan.

6a, 6b, 6c. 0.5 percent endrin + 2.0 percent Arasan: Same as treatments 4a-c, but with one-fourth the amounts of Arasan.

7. 8 percent talc: Seed was coated with talc at 8 percent by weight. The adhesive and aluminum were the same as in treatment 2a.

8. 0.5 percent endrin + 8 percent talc: A combination of treatments 2a and 7.

9. 0.5 percent endrin + 4 percent talc: Same as treatment 8, but with half the amount of talc.

10. 0.5 percent endrin + 2 percent talc: Same as treatment 8, but with one-fourth the amount of talc.

In all treatments except the control, seeds were wet with slurries of the chemicals in the adhesive, covered with a thin layer of aluminum powder, and allowed to dry overnight under a hood.

Bioassay

Two trials were conducted--consumption of: (1) untreated (control) seed was compared with that coated with either endrin, Arasan, talc, and endrin plus Arasan or talc, and (2) seed treated with endrin alone was compared with seed treated with endrin-Arasan at three levels of adhesive.

Deer mice (*Peromyscus maniculatus*) live-trapped near Tumwater, Washington, were used in all bioassays. Briefly, 10 seeds of one treatment were fed daily to each of 10 freshly caught mice for 5 consecutive days. Seed consumption was recorded daily and the numbers of dead mice were noted each day during the test and for 2 days following. Water and a commercial pelleted ration were offered *ad libitum* before and during each test. All bioassays were conducted in October, November, and December 1970.

Germination

Arasan and talc were ineffective in the bioassays, and the endrin-talc treatments had no practical importance; thus seeds from treatments 3, 7, 8, 9, and 10 were not germinated. Of the remainder, seeds from treatments 2a, 4a, 5a, 6a, and control were selected for testing to evaluate the effects of endrin and endrin-Arasan combinations on germination and seedling production.

Eight replicates of 100 seeds each were germinated on perlite at $24^\circ \pm 1^\circ$ C. after stratification for 21 days at 3° to 5° C. Four replicates were stratified before treatment and the other four after treatment. Germinants were counted at weekly intervals for 4 weeks.

To study seedling production and growth, replicates similar to those of the perlite tests, but of 35 seeds each, were planted about 1/8 inch deep in 4- by 4-inch pots containing equal amounts of soil, vermiculite, and peat moss. The pots were placed under growth chamber conditions described in Radwan et al. (1970), and after 50 days resulting seedlings were counted.

Statistical analysis

Bioassay and germination data were subjected to analysis of variance after arc-sine transformation. Means were separated according to Tukey's test (Snedecor 1961), or appropriate orthogonal comparisons were made as required.

RESULTS

Bioassay

Arasan or talc applied alone had no effect on seed consumption, but endrin and endrin plus Arasan or talc at all

levels significantly reduced feeding (table 1). More importantly, seed consumption was not significantly different among the endrin, endrin-Arasan, and endrin-talc treatments.

Increasing the ratios of adhesive to water caused significant increases in consumption of endrin and endrin-Arasan treated seed, but differences among treatments within a single level of adhesive were not significant (table 2).

Mortality of mice was low in all bioassays. Only six of the 180 test mice died as an apparent result of chemical treatments.

Germination

Within each treatment, germination on perlite and in soil differed little between seed stratified before and after treatment. This indicates that chemicals present on the seed during stratification had negligible effects on germination. Consequently, results were averaged for each treatment as shown in table 3. Also, germination on perlite was comparable with that in soil for all treatments.

Germination of treated seed was lower than the controls; a slight reduction in germination resulted from endrin, and a further significant decrease was evident when Arasan was present. Gross examinations of seedling tops and roots, however, indicated that seedling growth was not affected by the endrin or endrin-Arasan treatments.

DISCUSSION AND CONCLUSIONS

In this study we were unable to substantiate Arasan's repellency to deer mice (Spencer 1960). Our bioassay results show that action of Arasan was similar to

Table 1.--Consumption by deer mice of untreated and endrin-, Arasan-, and talc-coated Douglas-fir seed and resulting animal mortality

Treatment	Treatment number	Seed consumption ^{1/}	Animal mortality
- - - - Percent - - - -			
Control	1	100 x	0
0.5 percent endrin	2 a	43 y	0
0.5 percent endrin + 2.0 percent Arasan	6 a	50 y	0
0.5 percent endrin + 4.0 percent Arasan	5 a	50 y	0
0.5 percent endrin + 8.0 percent Arasan	4 a	39 y	0
8.0 percent Arasan	3	99 x	0
0.5 percent endrin + 2.0 percent talc	10	52 y	20
0.5 percent endrin + 4.0 percent talc	9	50 y	0
0.5 percent endrin + 8.0 percent talc	8	42 y	20
8.0 percent talc	7	99 x	0

^{1/} 10 animals, 10 seeds per animal per day, 5-day test. Means followed by the same letter do not differ significantly at the 5-percent level, using Tukey's test.

that of talc--an inert compound. Arasan alone was completely ineffective against deer mice and, when mixed with endrin, did not enhance effectiveness of the treatment. The chemical also caused significant reductions in germination in agreement with Shea (1961).

Deer mice do not eat whole conifer seed--they remove seedcoats to reach and consume the "endosperms." Thus, coated repellants are contacted and may be ingested during the hulling process. Clearly, the amount of repellant available to the animal would depend upon the concentration of the chemical in the coating and the degree of binding to the seedcoat by the adhesive. Accordingly, at the same level of adhesive (table 1), endrin was more concentrated in the coating and more tightly bound to the seed when the chemical was used alone than when it was present with other additives.

Adding Arasan (or talc) to the coating decreased the concentration of endrin and its binding to the seed. Thus, while there was less endrin per unit weight of coating in presence of Arasan (or talc), the chemical was less tightly bound to the seed and more available to the mice. We believe that this counteraction between endrin concentration in the coating and degree of binding by the adhesive was the cause for similar effectiveness of the endrin and endrin-Arasan treatments when the same amount of adhesive was used. We also suggest that the effectiveness in seed protection previously attributed to Arasan by us and others probably resulted from the use of different seed-treatment methods and (or) ingredients. For this study, we coated our seed uniformly using one method of treatment throughout, and we used the liquid Arasan 42-S rather than a solid formulation.

Table 2.--Consumption by deer mice of Douglas-fir seed coated with endrin and endrin-Arasan at three levels of adhesive and resulting animal mortality

Treatment	Treatment number	Seed consumption ^{1/}	Animal mortality
- - - - - Percent - - - - -			
0.5 percent endrin:			
1:9 adhesive	2 a	43 x	0
1:4 adhesive	2 b	66 y	0
1:1 adhesive	2 c	86 z	10
0.5 percent endrin + 2.0 percent Arasan:			
1:9 adhesive	6 a	50 x	0
1:4 adhesive	6 b	63 y	0
1:1 adhesive	6 c	93 z	0
0.5 percent endrin + 4.0 percent Arasan:			
1:9 adhesive	5 a	50 x	0
1:4 adhesive	5 b	63 y	0
1:1 adhesive	5 c	94 z	0
0.5 percent endrin + 8.0 percent Arasan:			
1:9 adhesive	4 a	39 x	0
1:4 adhesive	4 b	57 y	0
1:1 adhesive	4 c	95 z	10

^{1/} 10 animals, 10 seeds per animal per day, 5-day test. Means followed by the same letter do not differ significantly at the 5-percent level, using Tukey's test.

Table 3.--Germination of treated and untreated Douglas-fir seed on perlite and in soil

Treatment	Treatment number	Germination ^{1/}	
		Perlite	Soil
- - - - - Percent - - - - -			
Control	1	83	80
0.5 percent endrin	2 a	82	73
0.5 percent endrin + 2.0 percent Arasan	6 a	77	70
0.5 percent endrin + 4.0 percent Arasan	5 a	74	68
0.5 percent endrin + 8.0 percent Arasan	4 a	72	68

^{1/} In each column, orthogonal comparisons at the 5-percent level show that treatments containing Arasan are significantly different from those without the chemical, but there are no differences between control and endrin-only treatments.

The importance of the adhesive and the ineffectiveness of Arasan are illustrated further in table 2. Within the endrin and each of the endrin-Arasan treatments, increasing adhesive amounts increased seed consumption. However, differences among the four treatments within each of the three adhesive levels used were not significant.

There appears to be no justification for adding Arasan to endrin treatment to

protect Douglas-fir seed from deer mice. Whether Arasan provides protection from other seed-eating rodents, birds, or fungi commonly found in the Douglas-fir region is problematical. Preliminary data from a field study currently underway in western Oregon and Washington show that seed treated with endrin alone is equally as effective in producing seedlings as that treated with endrin plus Arasan (unpublished data). Dick et al. (1958) came to a similar conclusion.

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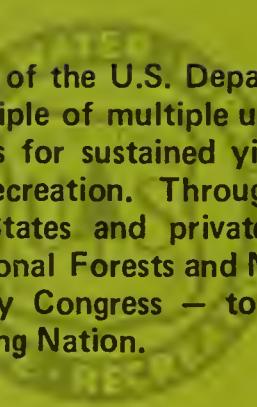
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